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"Mortality among Architeuthidæ." Professor Verrill (*Am. Journ. Sci.*, xxi, p. 251, Mar., 1881) notes a strange mortality of giant squids ("Architeuthis"), which, according to Capt. J. W. Collins, occurred in Oct., 1875. Twenty or thirty specimens were found floating on the water and secured for bait by the fishing fleet. They were mostly somewhat mutilated when found.

A novel mission in England sends beautiful sea-shells, which are generally collected by children, to little sick people in homes or hospitals. Since May, 1879, it has distributed a quarter of a million of shells from the West Indies, South Africa and Spain, as well as from the English coast.—*Foot's Leisure Hour*.

A specimen of *Tridacna gigas* Lam., weighing 528 pounds, was obtained by Professor Ward, of Rochester, New York, at Singapore. It was thirty-six inches long and twenty-seven broad, and was presented to the California State Mining Bureau, by Mr. J. Z. Davis.—*S. F. Bulletin*, Mar. 2d.

*Erratum*.—By an inexplicable and unfortunate "lapsus" in this record for 1880 (p. 716), the name of W. H. Ballou was substituted for that of Rev. W. M. Beauchamp, who should have been credited with the authorship of the note on the distribution of *Bythinia tentaculata* in the United States (cf. *AM. NAT.*, July, 1880, p. 523, and Mar., 1882, pp. 244-5).

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## THE ORGANIC COMPOUNDS IN THEIR RELATIONS TO LIFE.<sup>1</sup>

BY LESTER F. WARD.

IN a paper on the "Formation of the Chemical Elements,"<sup>2</sup> read March 29, 1879, before the Philosophical Society of Washington, I proposed the following *cosmical definitions* of the three principal known forms of matter:

"1. *Chemical Elements*.—Substances whose molecules are composed either of those of other chemical elements of less atomic weight, or of such as are too low to be capable of molar aggregation, and therefore imperceptible to sense: formed during the progress of development of star-systems at temperatures higher

<sup>1</sup> Read before the Philosophical Society of Washington, January 28, 1882; also read before the Biological Section of the American Association for the Advancement of Science at Montreal, August 29, 1882.

<sup>2</sup> "Evolution of the Chemical Elements," in the *Popular Science Monthly*, Vol. xviii (February, 1881), pp. 526-539.

than can be artificially produced, and hence too stable to be artificially dissociated.

“2. *Inorganic Compounds.*—Substances whose molecules are composed of those of chemical elements or of other inorganic compounds of lower degrees of aggregation: formed in the later stages of the development of planets at high but artificially producible temperatures, and therefore capable of artificial decomposition; and constituting the greater part of the solid crust of cooled-off bodies, their liquid, and a portion of their gaseous envelope.

“3. *Organic Compounds.*—Substances whose highly complex and very unstable molecules are composed of those of chemical elements, inorganic compounds, or organic compounds of lower organization: formed on the cooled surfaces of fully developed planets at life-supporting temperatures.”

In that paper I endeavored to show that the so-called chemical elements differ from one another in ways which strongly suggest the possibility that some of them may have been evolved from simpler constituents in much the same manner as the inorganic compounds are formed. These latter were therefore treated as simply forming the continuation of a uniform process of evolution, varied in its character only by the conditions of temperature affecting the globe at the period when these substances were respectively formed upon it. The passage above quoted from the same paper shows also that the development of the organic compounds was looked upon as the still further prolongation of this uniform law operating under the greatly lowered temperatures prevailing on the surface of the earth's crust after its formation. This law was further shown to be none other than that which is known to prevail in each of the higher domains of phenomena, in the mineral, the vegetable, and the animal world—the production of aggregates of higher orders of complexity through the re-compounding of units of lower degrees of simplicity. As indices of this law, and facts of primary significance, it was shown that throughout the scale, so far as traceable, even in the domain of the chemical elements, the molecules constituting each progressively more complex unit, exhibit *increase of mass* accompanied by *decrease of stability*.

The present paper will aim to take the subject up where the former left it, and to confine itself exclusively to an examination

of the last and highest of these products of Nature's alembic—the Organic Compounds.

These substances, as they exist on the globe, are for the most part products of organization, and they were long supposed to possess such subtle properties and composition as to be ever necessarily inscrutable to man. But quantitative chemistry has, within the last half century, not only succeeded in the complete analysis of all such substances obtained from organized beings, but it has also effected the synthesis, or reproduction out of their inorganic elements, of thousands of them. Thus Wöhler, Berthelot, Kolbe, Friedel, Piria, Wertheim, and others have accomplished the manufacture of such bodies as urea, formic, oxalic, lactic, and salicylic acid, numerous alcohols and ethers, glycerine, and a host of essences, including wintergreen, vanilla, mustard, cinnamon, camphor, etc., as well as alizarine and indigo dyes. These facts are sufficient to obliterate completely the line of demarkation formerly supposed to exist between the chemical constitution of inorganic and organic compounds, and when it is remembered that the latter differ as widely from one another as they do from the former in complexity, the uniform process of molecular aggregation cannot be regarded as interrupted at this stage. There is also much indirect evidence, though amounting to proof in but few cases, that the organic compounds, at least some of them, are sometimes directly formed by nature out of their inorganic constituents without the intervention of organized bodies.

These substances have their peculiar properties depending, like those of all other substances, on their molecular constitution; the artificial glycerine possesses the same sweet taste as the natural product, the manufactured spices yield the same aromas, and the laboratory dyes the same colors as those of the Orient. Many organic compounds are exceedingly complex, their molecules being relatively large, containing several thousand times as much matter as a molecule of hydrogen. Their instability, moreover, bears some proportion to their complexity. Most of them are colloidal in structure and refuse to crystallize; a few of the simpler ones, however, in which the proportion of oxygen is large, as sugar, for example, become crystalline under certain conditions.

The only element which is never absent from any of these compounds is carbon. Oxygen is almost universally present, and the

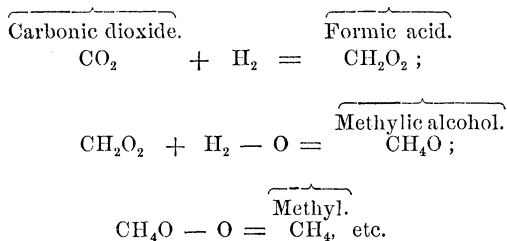
hydrocarbon group from which it is wanting is quite distinct from all others. Hydrogen comes next in point of regularity, and these three elements make up the great bulk of all organic matter. When nitrogen is added a marked change is made in the nature of the compounds. The nitrogenous group is distinguished especially by its great instability, and also by the number of isomeric forms which these bodies are capable of assuming. The only other elements that enter to any great extent into organic compounds are sulphur and phosphorus. These occur in limited but definite proportions in many of the most complex substances.

The remarkable contrasts which the elements of organic compounds present when compared with one another have been frequently pointed out by different writers, and they are certainly adequate to explain most of the properties possessed by these bodies. The chief characteristic of oxygen is its great chemical activity, or tendency to combine with other substances, while that of nitrogen is its inertia, or inability so to combine. Carbon is a solid at all temperatures producible on the globe, while all the other three chief constituents of organic matter are practically incapable of solidification. This fact is a measure of the degree of cohesion of the homogeneous molecules composing the respective molar aggregates; that of carbon is intense, while that of hydrogen is exceedingly slight. While this in each case depends on the degree of heat, it will be relatively the same among them all at any given temperature.

It would appear that all the attempts, so to speak, on the part of nature to form compounds of the gaseous elements alone have resulted, where successful, in substances which are at once pronounced inorganic, such as water,  $\text{H}_2\text{O}$ , ammonia  $\text{NH}_3$ , nitric acid,  $\text{HNO}_3$ , etc. It is remarkable that while the chief compound of the two persistent gases, hydrogen and oxygen, is liquid (water) or solid (ice) at our temperatures, that formed of the persistent solid, carbon, in combination with one of these gases, oxygen (carbonic dioxide,  $\text{CO}_2$ ), is a gas at all ordinary temperatures and pressures. Notwithstanding this, it can not be doubted that carbon is the agent which, by its great molecular cohesion prevents the dissolution of the higher compounds and renders organic substances possible.

As already remarked, the transition from the inorganic to the organic is, from the point of view of chemical structure, purely

nominal, and the existence of any hard and fast line marking off one of these fields from the other has long been denied. If there were any advantage to be derived from such a line perhaps it could not be drawn in a better place than that where carbon unites with hydrogen or nitrogen, either with or without oxygen. This, it is true, would place all the hydrocarbons, as well as cyanogen in the organic series. On this view, therefore, the inorganic compound most nearly related to the organic series would be carbonic acid, or, as it is now more properly called, carbonic dioxide,  $\text{CO}_2$ , of whose inorganic origin there can be no doubt. The simplest organic compounds consist chiefly in the addition of different proportions of hydrogen to this basis and the reduction of the proportion of oxygen. In the various hydrides (methylic,  $\text{CH}_4$ , ethylic,  $\text{C}_2\text{H}_6$ , amylic,  $\text{C}_5\text{H}_{12}$ , etc.), the oxygen disappears altogether. In the alcohols it reappears only in the addition of one oxygen molecule, to the respective hydrides. The acids result from an additional increase in the proportion of oxygen (formic,  $\text{CH}_2\text{O}_2$ , acetic,  $\text{C}_2\text{H}_4\text{O}_2$ , etc.). The actual development of the organic compounds, as it may be supposed to take place in nature, would seem to be in the reverse order to that above given, the organic acids being first formed from inorganic compounds by the addition of hydrogen, then the alcohols from these by still further increase of hydrogen accompanied by a reduction of oxygen, and lastly, the hydrides from the alcohols by the loss of the one equivalent of oxygen remaining in the latter. The different kinds of acids, alcohols, and hydrides, arise from varying the proportions of hydrogen and carbon. The simplest change possible may be indicated thus :



When we look at the higher and more complex compounds, we can readily see that they may be composed of the lower ones as their molecular constituents. This is, to a great extent, assumed by chemists, and the chemical synthesis of a large num-

ber of these substances has been carefully worked out. In the formation of sugar ( $C_{12}H_{22}O_{11}$ ), starch ( $C_{12}H_{20}O_{10}$ ), gum ( $C_{12}H_{20}O_{13}$ ), etc., the proportion of oxygen is quite large, and the phenomena of crystallization may occur under certain circumstances.

The oils are a still more complex group, being formed by the union of very feeble acids with the common base, glycerine ( $C_3H_5O_3$ ). They are colloidal under all conditions, and decompose much more easily than the amyloids.

The most important organic compounds, however, especially from the biological point of view, are those containing nitrogen. These fall under two general classes, and constitute the so-called organic bases on the one hand, and the albuminoids on the other. The former of these groups have been for the most part extracted from vegetables of which they constitute the "active principles," or characteristic properties, although, as we saw, a large number of them have been artificially manufactured. As illustrations of the nature and composition of these substances may be mentioned, morphine ( $C_{17}H_{19}NO_3$ ), narcotine ( $C_{22}H_{23}NO_7$ ), quinine ( $C_{20}H_{24}N_2O_2$ ), strychnine ( $C_{21}H_{22}N_2O_2$ ), etc. It will be seen that the principal particulars in which these fundamentally differ from the organic compounds already considered, consist in the addition of a small percentage of nitrogen and the reduction of the proportion of oxygen; yet the properties which they possess are a hundred-fold more active.

The composition of the organic bases, however, though somewhat complex, is simple compared with that of the albuminous compounds. These contain, in addition to the elements of the former, small, but rather definite proportions of both sulphur and phosphorus. The number of molecules of each of the components indicates a large, complex molecule as the unit of composition. The expression for albumen as given by Liebig was:  $C_{216}H_{338}N_{54}S_3O_{68}$ . Could this be relied upon this substance would contain 679 equivalents of different weights, which, when reduced to the standard of hydrogen, would indicate a molecule for albumen 4870 times as large as the hydrogen unit. The molecule of fibrin is supposed to be still larger than that of albumen.

The substances thus composed, as we should naturally expect, are very unstable and possess remarkable properties. They constitute the substance of the muscles and nerves of the animal sys-

tem and the fibrin of blood. They are also found in all cells whether animal or vegetable. The base of the entire group is known as *protaine*, so named from its remarkable power of assuming different isomeric forms, of which it presents some thousand or more. *Proteine* contains no sulphur nor phosphorus, and its formula as given by its illustrious discoverer, Mulder, is,  $C_{18}H_{27}N_4O_6$ . Each of its units would thus be composed of 65 elementary molecules, the combined mass of which would be equal to 395 molecules of hydrogen. All the actual known substances of this group have, therefore, more complex molecules than those of this still, to a great extent, theoretical one.

While the albuminoids possess none of the active properties of the organic bases, they far exceed them in the power they have to change their form, and adapt themselves to the needs of organized beings. All properties in material bodies are the result of reactions taking place in their molecular constitution when brought into contact with other bodies. They are recognized only when they directly or indirectly affect the senses. As a rule, the larger their molecules, the more powerful their effects. In the case of the albuminoids, with their comparatively enormous units of aggregation, the entire substance is transformed with only slight external influence, either of heat or chemical contact, and either assumes new characters or breaks up into the simpler organic compounds of which it is composed.

The general law above stated, that in the progress of the evolution of matter from the simplest elemental state to the most complex organic compound, there has constantly been increase in the mass and decrease in the stability of the molecules, holds good throughout, and to it may now be added a third principle, obviously correlated with the above, and merely constituting a corollary to it, that *pari passu* with these changes there has been an *increase in the activity of the properties* manifested by the substances evolved.

Although varying through wide degrees in this respect, all the substances thus far mentioned possess sufficient stability to be retained, handled, and examined, and to the ordinary observer they present very much the same general appearance. While possessing many special qualities distinguishing them from other bodies, the albuminoids, as well as all the other organic compounds, appear to be and are incapable of any visible automatic movement.



We are obliged, however, to suppose that these, like other solids, even the densest crystals or metals, possess at all times molecular activities. It is these activities that determine the respective properties of all substances, and constitute the multiple and varied in nature. In proteine bodies, these molecular activities are much more extensive and varied than are those of simpler bodies. The molecular units are so much larger that their motions must be, as it were, *molar* in comparison, while within these larger primary units there are lesser units of different orders of aggregation, each of which manifests its own appropriate activities, and thus modifies the general properties of the whole. The reason why we are unable to see these motions, is simply because they are still on far too small a scale to be directly observed either by the eye or by any of the appliances yet devised for intensifying human vision.

The development of the albuminoids, highly complex as they are, is not alone sufficient for the immediate genesis of life. A form of matter still more complex, must be reached before this result is possible. But there is no evidence that this form of matter is produced by any different process from that by which other forms of matter are produced. From the molecule of hydrogen to that of albumen, the process of evolution has been uniformly the same, viz., that of compounding and recompounding, of doubly and multiply compounding; in short, it has been the process of molecular aggregation. It would be contrary to the law of uniformity in natural phenomena, upon the recognition of which modern science is based, to assume an abrupt change in the process at this point, and upon those who maintain such a *saltus* must rest the burden of proof.

Dealing, as we constantly must do, with molecules only, we are able to form conclusions only from observed effects, but we have seen that, without changing the elementary substances which analysis can demonstrate to be present at any stage of the process, with each new step in the progress of aggregation new and higher properties are created. From the inert properties of carbon and nitrogen in the free state, of water and carbonic acid, the simplest compounds, we have, by further successive compounding, the more active ones of ammonia and nitric acid, the sweet taste of sugar and glycerine, the powerful narcotic principles of nicotine and morphine, the deadly toxic properties of

strychnine, and, manifesting themselves in a wholly different manner, the still higher order of properties, including those of isomerism, exhibited by the proteine bodies; all of which we seem bound to ascribe to the respective orders of combination and complication, under which these substances, possessing the same elementary constituents, exist when they display these qualities. In short their properties must be regarded as the result of the respective molecular constitution of each substance.

With still higher states of aggregation, could such be conceived as possible, we should therefore naturally expect still higher forms of activity, still more marked properties. But we have learned that, while we may safely predict higher properties from higher degrees of aggregation, we have no basis whatever upon which to predict the nature of these properties. Not even in the simplest inorganic re agencies can we foretell the result of the union of any two elements. We cannot even say which of the three states of matter, the gaseous, the liquid, or the solid, our new compound will exhibit at our temperatures. The invincible solid, carbon, when joined with oxygen, becomes a gas; the type of gases, hydrogen, when combined with another gas, oxygen, results in a solid at 32° Fahr. Much less can we predict the other more special properties, even of these primary compounds. *A fortiori* is human prevision inadequate to presage the result of organic combinations. That the re-compounding of the proteine bodies should result in a new form, possessing the quality of spontaneous movement is *a priori* just as probable as that the addition of a molecule of oxygen should convert the hydrides into alcohols.

This complex stage of aggregation is no longer an hypothetical one. The molar aggregate resulting from such a recompounding of the albuminoids has been discovered. It exists under diverse conditions and manifests properties fully in keeping with its exalted molecular character. This substance, discovered by Oken in 1809, and by him denominated *Urschleim*, recognized by Dujardin in 1835, and called *sarcode*, and thoroughly studied by Mohl in 1846, who named it *protoplasma*, has now passed unchallenged into the nomenclature of modern organic chemistry under the last mentioned designation.

Protoplasma is a chemical substance, found in considerable abundance in nature, not only within the tissues of organized

beings, but as we might almost say, in a mineral state, wholly disconnected from such beings. There is no more doubt that it is a natural product than there is that ammonia is such a product. Its composition has been ascertained with considerable accuracy, and is found to be substantially the same under whatever form it may occur. According to the highest authorities this substance contains, approximately, fifty-four parts of carbon, twenty-one parts of oxygen, sixteen parts of nitrogen, seven parts of hydrogen, and two parts of sulphur in one hundred parts. These proportions doubtless vary somewhat, and traces of other ingredients may, perhaps, be occasionally detected, but the above description is sufficient to fix the chemical character of protoplasm. To write its symbolic formula is impossible in the present state of science, but so is it still impossible, to write that of the albuminoids with any reliable accuracy. Their numerous isomeric forms show us that the grouping of the molecules is subject to constant changes. This is doubtless true to a far greater extent of protoplasm. It is a substance whose molecular units are probably compounded of the units of the proteine bodies, which enter bodily into them in the same manner that oxygen and hydrogen enter into water, or, as we suppose ammonia, carbonic acid, and the compound radicals to enter into the more complex organic compounds.

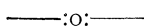
The many conditions under which protoplasm is found to exist on the globe, may for convenience, be divided into two general classes: the free, and the dependent state. It is a matter of fact that it is found in a free state under a number of forms, both in the sea and in fresh water, and such bodies as Haeckel's *Protogenes*, and Huxley's *Bathybius* are simply representatives of it in this condition. On the other hand, protoplasm is present in all organisms, whether animal, vegetable, or protist, and of which, though small in relative quantity, it constitutes by far the most important of all their material constituents. To distinguish the wholly independent, amorphous, and spontaneously developed form of protoplasm above described from that which is found in the tissues of organisms and inseparable from them, Professor Haeckel proposes to apply to it the term *plasson*, or *plasson bodies*, which, while it should not lead to the notion that there is any essential difference in the matter itself, is convenient to aid in retaining the conception, not generally acknowledged, of its purely chemical character.

It is, however, difficult to describe the properties of the plasmon bodies without giving rise to the idea of life, since the leading one is that of spontaneous mobility, or motility, as it has been technically called. Anything that moves is naturally supposed to be alive, and if this were a test of life, all forms of protoplasm would be living things. And, indeed, there would be really no objection to this view, provided the idea of life could be rigidly confined to this and a few other simple phenomena. But the tendency is always strong to couple with the notion of life that of *organization*, and few can be brought to recognize either that life can be the product of chemical organization, or that it can precede morphological organization. We are apt to associate with the conception of life, that of nerves, muscles, joints, limbs, stomach, and even sense organs. From the plasmon bodies all these are as completely wanting as from a lump of gypsum. The spontaneous movements and all the transformations through which these substances pass, only constitute the mode in which their chemical activities manifest themselves. These activities belong to them in the same sense that sweetness belongs to sugar or astringency to alum. In fact, the primary distinction between these most complex of all known bodies, and the less complex ones seems to be, that while in the latter all their activities are molecular, in the former they are to a certain extent molar, and carry with them the whole or a portion of the substances themselves.

The plasmon bodies have recently been made to constitute a special field of scientific research, and as much by accident as otherwise, it has been occupied by the biologists instead of by the chemists. These, like judges on the bench, have constantly ruled in favor of their own jurisdiction, and it is in this way that these substances have come to be regarded as forms of life, although their biographers have from the first insisted that they are not organized beings. Perhaps this bit of history is not unfortunate, since it teaches us to disconnect the ideas of life and organization in the biological sense, and thereby directs our thoughts towards the most profound truth, both of biology and of chemistry, which is that life is the result of the aggregation of matter. A plasmon body performs all the essential functions of a living organism. It is capable of motion, nutrition and propagation. To these Professor Haeckel adds sensation, for how can the other functions be conceived of without the aid of this one? But we might almost

as well ask, how can a crystal grow without sensation. Nor has that great naturalist failed to perceive these extreme consequences of this extension of the biological jurisdiction, for he seeks to escape them only by pushing it still farther, and proclaiming the animation of all material atoms, even of the lowest orders—*die Atom-Seele*. It seems far simpler, as well as more correct, to recognize in protoplasm a true chemical substance, but one whose properties constitute the fundamental element of life.

Such a conclusion is no longer the bold speculation that it would have been pronounced a few years ago, and this paper could not be more fittingly concluded than with the words of Professor O. C. Marsh, uttered in 1877, that “if we are permitted to continue in imagination the rapidly converging lines of research pursued to-day, they seem to meet at the point where organic and inorganic nature become one. That this point will yet be reached, I cannot doubt.”



## THE REPTILES OF THE AMERICAN EOCENE.

BY E. D. COPE.

REMAINS of *Batrachia* are rare in North American formations later than the Permian. There are two or three species of *Stegocephali* known from the Trias, above which formation that order is not known to extend in any country. No Batrachians have been obtained from the Jurassic or Cretaceous systems excepting from the top of the latter, in the Laramie. Here occur the salamandrine genera *Scapherpeton* and *Hemitrypus* Cope. A single specimen of a frog from the Eocene is mentioned below, and then we miss them until the Loup Fork or Upper Miocene, where *Anura* and salamanders have been found.

The vertebral column and part of the cranium of a probably incompletely developed tailless Batrachian, were procured by Dr. F. V. Hayden, from the fish shales of the Green River epoch, from near Green River City, Wyoming. They are not sufficiently characteristic to enable me to determine the relation of the species to known forms. It is the oldest of the order *Anura* yet discovered, the fossil remains of the known extinct species having been derived from the Miocene and later formations of Europe.

The Eocene period, was, of the divisions of the Tertiary, the